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Efficacy of Forest-Thermal Combined Therapy for Anxiety and Stress among Smoking-Cessation Attempters

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Purpose: Smoking is a way of coping with anxiety and stress. This study aimed to identify the effects of forest-thermal combined therapy on anxiety and depression in smokers who desire to quit smoking. **Methods:** Thirty participants were included in the study, 15 in the experimental group and 15 in the control group. Those in the experimental group participated in a three-day forest-thermal combined therapy program. The program includes forest walks, meditation and thermal therapy in the charcoal kiln. **Results:** Before and after the program, physiological indicators such as cortisol, heart rate variability, and serotonin anxiety level using the state-trait anxiety inventory (STAI), and stress level using the psychosocial well-being index (PWI) were measured in both groups. The differences in STAI (p = .012) and PWI (p = .006) scores between the experimental and control groups were statistically significant. However, cortisol, heart rate variability, and serotonin were not significantly different between the two groups after the program. **Conclusion:** These results show that forest-thermal combination therapy effectively reduces anxiety and stress in smokers. It suggests that forest-thermal therapy can potentially increase smoking cessation rates.

Key Words: *Anxiety; Forest; Stress; Thermotherapy; Smoking*

INTRODUTION

Smoking is a major cause of respiratory diseases, such as chronic obstructive pulmonary disease (COPD) and lung cancer worldwide, and is closely associated with coronary artery disease (CAD), stroke, and cancer [1]. The 2022 National Health Statistics Report estimated 34.0% of men and 6.6% of women in South Korea to be current smokers as of 2020 [2], revealing Korean men's smoking rate to be the highest among OECD countries, despite their gradually decreasing smoking rate from the peak level of 43.7% in 2012 [3].

Although it is commonly believed that smoking helps manage stress [4], smoking is frequently associated with anxiety, depression, and agitation due to a vicious cycle of smoking, nicotine withdrawal, and smoking again to maintain the blood nicotine content [5]. Also, stress hormone increases during withdrawal period by the strong neurophysiological action of nicotine [6]. The smoking group had a 1.62-fold higher risk of stress compared with the non-smoking group in a study conducted by Bin [7]. Furthermore, smoking is closely associated with mental health problems, such as social anxiety and stress, as well as physical illness [7,8].

With increasing awareness of the harmful effects of smoking, efforts are made to implement population-level support for smoking cessation and regulation as strategies for reducing the burden of smoking-related diseases. Smoking cessation is one of the major health promotion agendas, and the South Korean government is actively pursuing smoking

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cessation strategies as a core task of its Health Plan 2030 [9]. In 2018, 47.3% of Korean adult smokers (≥19 years) attempted to quit smoking [10]. Although nearly half of smokers have a smoking cessation intention, only 12% to 35% of them succeed, with smoking cessation defined as continuous abstinence for over six months up to 24 months [11–13]. More than half of the respondents (52.6%) chose "stress" as the reason for the difficulty associated with smoking cessation, with "increased stress" being the main cause of smoking initiation and failure in smoking cessation [14,15]. This highlights the importance of mental health management, such as stress and anxiety, for those attempting to quit smoking.

Forest therapy is a natural therapy designed to help restore psychological and mental stability and improve physical and mental health by using a diverse forest environment to interact and communicate with nature [16]. Forest therapy suppresses sympathetic nerve activity [17,18], reduces cortisol levels [17,19], increases parasympathetic nerve activity [18], and reduces mental stress, anxiety, and anger [20,21].

Dry sauna therapy, a type of thermotherapy that has long been used in many countries to provide pleasure and relaxation [22,23], is perceived as a method to alleviate stress [22]. Charcoal kiln saunas have long been a tradition in Korea. Their health effects are attributable to the far-infrared radiation emitted from yellow ocher clay and the anions (negatively charged ions) emitted from charcoal that penetrate deep into the body and stimulates metabolism by excreting heavy metals and waste matter through sweat, stool, and urine, thus helping prevent various diseases [24]. They have the effect of relaxing the body and mind and alleviating anxiety [25]. Taken together, forest therapy and thermotherapy are effective interventions for stress and anxiety management. They can be used as alternatives to facilitate smoking cessation for those who attempt to quit smoking.

Therefore, this study aimed to examine the effects of forest-thermal combined therapy in reducing anxiety and stress by applying it to smokers with smoking cessation intentions. The results can serve as preliminary data for developing effective and economical smoking cessation programs for widespread use in communities.

METHODS

1. Design

This study used a nonequivalent control group pre-and post-test design to examine the effects of forest-thermal combined therapy on stress and anxiety as an intervention program.

2. Participants

The participants of this study were smoking cessation attempters and were enrolled in a smoking cessation clinic at a community health center in C city. Prior to the initiation of any study-related procedure, approval was obtained from the institutional review board of K University (KWNUIRB-2020-06-001-003). The selection criteria for participant recruitment were as follows: adults (≥19 years) with no communication disorders, capable of understanding and responding to the questionnaire items, and without mobility limitations. Patients diagnosed with serious cardiovascular disease were excluded. Written and signed consent was obtained from each participant who voluntarily agreed to participate in the study after being given sufficient explanations about the necessity, purpose, invasive treatment, research method, and duration of the study, as well as their rights to withdraw their participation at any time without any disadvantages. Those who agreed to participate in the three-day and two-night program were assigned to the experimental group and the rest to the control group (15 each, totaling 30 participants).

3. Forest-Thermal Combined Therapy

The experiment was conducted during a stay of three days and two nights from May 14 to May 16, 2021. During the implementation of the forest-thermal combined therapy program, they stayed in a camp built in the natural recreational forest at the study site. The experimental group was exposed to the intervention program consisting of forest therapy in the morning and thermotherapy (heat bathing) in the afternoon during the three-day stay. The program, which consisted of meditation and walking, was operated by a forest therapist. Heat bathing (90-100°C) was taken for 15 minutes in a traditional charcoal kiln, followed by a 15-minute break outside wrapped with a blanket, and this 30-minute cycle was repeated four times for two hours (Figure 1). The control group was instructed to continue their daily routine without visiting natural environments such as urban parks or forest environments.

4. Data Collection

The pre-test survey was conducted at K University, where the stress and anxiety levels of the experimental and control groups were measured via a structured self-administered questionnaire. Upon completion of the pre-test survey, heart rate variability (HRV) testing was conducted in a quiet, closed space, followed by blood pressure measurement and blood sample collection (for the purpose of measuring blood concentrations of

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Figure 1. Images of forest-thermal combined therapy experiment.

cortisol and serotonin) in a different room. Blood samples were collected at 8 and 10 a.m. after fasting overnight for at least eight hours.

A post-test survey (identical to the pre-test survey) for the experimental group was conducted in the forest camp upon completion of the three-day residential intervention program of the forest-thermal combined therapy. This post-test was also administered to the control group in the university laboratory, where the pre-test survey was conducted.

5. Materials

The participants' general characteristics, age, gender, weight, education, religion, marital status, monthly income, drinking status, and nicotine dependence were investigated.

1) Stress

Stress was measured using Jang's [26] 18-item Psychosocial Well-being Index-Short Form (PWI-SF)—the revised Korean version of the scaled version of Goldenberg and Hiller's [27] —General Health Questionnaire (GHQ-28)—which is widely used in Korea. Each item of the PWI-SF was rated on a 4-point scale (0 = *Always true*, 1 = *Mostly true*, 2 = *Somewhat true*, 3 = *Never true*), with responses to negative items reverse-scored. A lower total score indicates a lower stress level. PWI-SF total scores were classified into three categories: *not-at-risk* (≤ 8), *potentially-at-risk* (9–26), and *at-risk* (≥ 27). Cronbach's α was .92 at the time of scale development and .95 in the current study.

2) Anxiety

Anxiety was measured using the State-Trait Anxiety Inventory (STAI) developed by Spielberger [28] and standardized for Koreans [29]. STAI, which is a self-reported instrument that measures the level of currently-perceived anxiety (*state anxiety*) and generally-perceived anxiety (*trait anxiety*), consists of 20-item state anxiety and 20-item trait anxiety subscales. Each item is rated on a 4-point Likert scale (1 = *Not at all*, 2 = *Somewhat*, 3 = *Moderately so*, and 4 = *Very much so*), with positive items reverse-scored. Each subscale score, the sum of each item, ranges from 20 to 80 points, where a higher total score indicates a higher anxiety level. Cronbach's α was .89 in Kim and Shin's [29] study and .98 in the current study.

3) Cortisol

Serum was used to measure cortisol (a stress hormone) levels. For serum cortisol analysis, assays of serum cortisol samples were prepared by collecting 3-mL whole blood samples and centrifuging them at 3000 rpm at room temperature for 7 minutes. The serum cortisol samples thus prepared were placed in an ice box and sent to the E laboratory for analysis using the chemiluminescent enzyme immunoassay (CLEIA) method. A higher cortisol level indicates a higher stress level.

4) Serotonin

Serotonin is a neurotransmitter that helps maintain a calm state of mind by suppressing arousal hormones such as dopamine, thus preventing one from getting too excited and feeling anxious. Serotonin levels were measured between 8 and 10 a.m. after overnight fasting. For serum serotonin analysis, 3-mL whole blood samples were collected, centrifuged at 3,000 rpm for 7 minutes, placed in an ice box, and sent to the E laboratory for analysis using high-performance liquid chromatography (HPLC). Symptoms of serotonin deficiency include anxiety, depression, drug and alcohol abuse, binge eating, headache, and other disorders that make daily life difficult [30]. In this study, the higher the serotonin level, the more comfortable and calm the participants were likely to feel.

5) Heart Rate Variability (HRV)

HRV was measured for 5 minutes using the HRV SA-3000P analyzer (Medicore Co., Ltd, Seoul, Korea) in a comfortable sitting position in a quiet test room to control factors that may affect the autonomic nervous system during measurement. In this study, measures of HRV included standard deviation of normal-to-normal intervals (NN interval), standard deviation of the NN interval (SDNN), mean heart rate (mHR), low frequency (ln-LF), high frequency (ln-HF), and LF/HF ratio that reflect sympathetic and parasympathetic nervous system activities.

6. Statistical Analysis

The homogeneity between the experimental and control groups was

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Table 1. Demographic Characteristics and Nicotine Dependency for the Groups (N = 30)

Characteristics	Categories	Exp. (n = 15) Mean ± SD/n (%)	Cont. (n = 15) Mean ± SD/n (%)	z, χ^2 or t	*p*
Age (yr)		40.07 ± 14.72	40.13 ± 12.25	-0.23	.819
Gender	Male	12 (80.0)	14 (93.3)	1.15	.598†
	Female	3 (20.0)	1 (6.7)		
Weight (kg)		68.53 ± 9.44	78.53 ± 18.11	-1.64	.101
Education	≤ High school	9 (60.0)	5 (33.3)	2.14	.143
	≥ College	6 (40.0)	10 (66.7)		
Religion	Yes	5 (33.3)	7 (46.7)	0.56	.456
	No	10 (66.7)	8 (53.3)		
Marital status	Married	7 (46.7)	9 (60.0)	1.92	.613†
	Single	6 (40.0)	6 (40.0)		
	Others	2 (13.3)	0 (0.00)		
Monthly income (Million KRW)	< 2	2 (13.3)	3 (20.0)	0.67	.791†
	2-4	4 (26.7)	5 (33.3)		
	> 4	9 (60.0)	7 (46.7)		
Drinking alcohol	Yes	14 (93.3)	13 (86.7)	0.37	1.000†
	No	1 (6.7)	2 (13.3)		
Nicotine dependency		3.80 ± 2.93	3.20 ± 1.78	0.68	.505

†Fisher's exact test.
Cont. = control group; Exp. = experimental group; SD = standard deviation.

Table 2. Values of Dependent Variables for the Groups (N = 30)

Categories	Variables	Exp. (n = 15) Mean ± SD	Cont. (n = 15) Mean ± SD	z or t	*p*
Stress	PWI-SF	20.07 ± 9.07	20.27 ± 8.70	-0.44	.662
Anxiety	STAI-S	40.20 ± 10.67	41.13 ± 13.60	-0.21	.836
	STAI-T	39.80 ± 8.50	41.00 ± 13.63	-0.29	.774
Cortisol (μg/dL)		13.91 ± 5.45	12.84 ± 2.89	0.67	.508
Serotonin (ng/mL)		101.18 ± 33.96	112.01 ± 49.50	-0.85	.395
HRV	SDNN	51.35 ± 30.89	35.48 ± 16.84	-1.40	.163
	mHR	67.40 ± 13.28	70.07 ± 11.16	-0.58	.564
	lnLF	5.62 ± 1.67	5.08 ± 1.05	1.05	.304
	lnHF	5.74 ± 1.56	5.35 ± 0.96	0.82	.421
	LF/HF ratio	1.15 ± 0.82	1.04 ± 1.07	-0.74	.458

Cont. = control group; Exp. = experimental group; SD = standard deviation; PWI-SF = psychosocial well-being index short form; STAI-S = anxiety inventory-state; STAI-T = anxiety inventory-trait; HRV = heart rate variability; SDNN = standard deviation of normal NN intervals; mHR = mean heart rate; LF = low frequency; HF = high frequency; ln = natural log.

analyzed using the t-test, χ^2 test, and Fisher's exact test. Independent t-test was performed on the variables for the experimental and control groups to analyze their effects on stress and anxiety. The significance level was set at $p < .05$, and statistical analysis was performed using IBM SPSS Statistics for Windows, Version 22.0 (IBM CO., Armonk, NY, USA).

RESULTS

1. General Characteristics of the Participants

The experimental group's mean age was 40.07 (± 14.72), while the control group's was 40.13 (± 12.25). Men outnumbered women, accounting for 80% of the total sample size. No significant differences were found between the experimental and control groups in age, gender, weight, education, religion, marital status, monthly income, drinking status, and nicotine dependence, showing homogeneity between them (Table 1).

Intergroup homogeneity in dependent variables was also established. No significant differences were found in the levels of HRV, serotonin, cortisol, stress, and anxiety (Table 2).

2. Effect of Forest-Thermal Combined Therapy

A comparison of pretest and posttest measures revealed that the mean stress level (PWI-SF score) was significantly reduced in the experi-

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Table 3. Effects of Forest-Thermal Combined Therapy (N = 30)

Variables	Group	Baseline Mean ± SD	After Mean ± SD	Difference Mean ± SD	t	*p*
Stress (PWI-SF)	Exp.	20.07 ± 9.07	11.13 ± 9.18	-8.93 ± 7.81	-2.96	.006**
	Cont.	20.27 ± 8.70	18.33 ± 9.33	-1.93 ± 4.82		
Anxiety						
STAI-S	Exp.	40.20 ± 10.67	32.07 ± 8.89	-8.13 ± 8.53	-2.68	.012*
	Cont.	41.13 ± 13.60	40.00 ± 12.18	-1.13 ± 5.48		
STAI-T	Exp.	39.80 ± 8.50	34.20 ± 7.03	-5.60 ± 5.69	-1.99	.056
	Cont.	41.00 ± 13.63	39.60 ± 10.86	-1.40 ± 5.85		
Serotonin (ng/mL)	Exp.	101.18 ± 33.96	116.23 ± 31.16	15.05 ± 17.02	-1.18	.247
	Cont.	112.01 ± 49.50	135.28 ± 61.31	23.27 ± 20.81		
Cortisol (μg/dL)	Exp.	13.91 ± 5.45	14.76 ± 5.64	0.85 ± 6.10	0.91	.371
	Cont.	12.84 ± 2.89	12.07 ± 4.22	-0.78 ± 3.26		
HRV						
SDNN	Exp.	51.35 ± 30.89	47.39 ± 29.35	-3.96 ± 24.86	-0.66	.515
	Cont.	35.48 ± 16.84	36.28 ± 22.77	0.80 ± 11.93		
mHR	Exp.	67.40 ± 13.28	64.00 ± 9.54	-3.40 ± 8.77	-1.78	.087
	Cont.	70.07 ± 11.16	72.00 ± 11.82	1.93 ± 7.26		
lnLF	Exp.	5.62 ± 1.67	5.64 ± 0.98	0.02 ± 1.18	-0.26	.800
	Cont.	5.08 ± 1.05	5.20 ± 1.13	0.12 ± 0.96		
lnHF	Exp.	5.74 ± 1.56	5.79 ± 1.26	0.05 ± 0.83	0.95	.352
	Cont.	5.35 ± 0.96	5.11 ± 1.45	-0.24 ± 0.81		
LF/HF ratio	Exp.	1.15 ± 0.82	1.13 ± 0.82	-0.02 ± 1.02	-1.22	.222
	Cont.	1.04 ± 1.07	2.09 ± 2.56	1.05 ± 2.05		

*p < .05, **p < .01.
Cont. = control group; Exp. = experimental group; HF = high frequency; HRV = heart rate variability; ln = natural log; LF = low frequency; mHR = mean heart rate; PWI-SF = psychosocial well-being index short form; SD = standard deviation; SDNN = standard deviation of normal NN intervals; STAI-S = anxiety inventory-state; STAI-T = anxiety inventory-trait.

mental group (t = -2.96, p = .006). Whereas the experimental group showed a significant reduction in the STAI-S score (state anxiety score, i.e., level of currently-perceived anxiety) compared with the control group (t = -2.68, p = .012). No significant intergroup difference was observed in the STAI-T score (trait anxiety score, i.e., level of generally-perceived anxiety), although the experimental group showed a higher degree of reduction than the control group (t = -1.99, p = .056) (Table 3).

No significant differences were found between the experimental and control groups in the levels of serotonin or cortisol among the physiological variables.

The analysis of HRV measures revealed no statistically significant intergroup differences in sympathetic and parasympathetic nervous system activities, SDNN or LF/HF ratio. The experimental group's mean HR was reduced, but not to the extent of showing a significant difference compared with the control group (Table 3).

DISCUSSION

Koreans have traditionally used charcoal kilns as a means of psychological and physical well-being. This study explores the psychological and physiological effects of an intervention program for smoking cessation attempters on their anxiety and stress levels using forest-thermal combined therapy, a natural therapy combining forest therapy and heat bathing in a charcoal kiln. Specifically, by examining the differences in perceived levels of stress and anxiety and physiological indicators such as HRV, serotonin, and cortisol between the experimental group, which participated in the three-day residential intervention program while the control group maintained their usual routines, it was intended to determine the applicability of the forest-thermal combined therapy as an auxiliary smoke cessation therapy to support smokers with smoke cessation intentions.

The psycho-emotional effects of the intervention program were demonstrated by the significant reductions in the perceived stress and state anxiety levels (PWI-SF and STAI-S scores, respectively) in the experimental group. These results are in line with those of previous studies on forest therapy [17,19,31] and thermotherapy [22,23]. This suggests that the proposed three-day residential program of forest-thermal combined therapy has a positive effect on stress and anxiety reduction in smokers

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willing to quit smoking. This may be ascribable to the stress-reducing effects of forest therapy by activating parasympathetic nerves, leading to physiological relaxation [17], as well as the anxiety-alleviating effects of thermotherapy by promoting metabolism [24] and relaxing the body and mind [25].

It has been reported that stress acts as a major determinant of the incidence and frequency of smoking [32]. Stress is often cited as the main factor that drives adolescents to attempt smoking [33], and mood improvement, that is, stress reduction, is cited as the main reason for smoking [34]. Stress was also found to be the main obstacle to smoking cessation (52.6%) [36]. In a Korean study, the moderate- and high-stress groups had 1.52- and 2.34-fold higher smoking rates, respectively, compared to the low-stress group, demonstrating a high correlation between stress level and smoking [32]. Thus, stress reduction through forest-thermal combined therapy can contribute to reducing the prevalence of smoking, which might, consequently, lead to individual health promotion and disease prevention. In addition, there is a high correlation between smoking and anxiety, which can be bidirectional because smoking is initially attempted to relieve anxiety symptoms, but eventually worsens those symptoms by developing withdrawal symptoms [35]. In this study, it was found that the forest-thermal combined therapy was effective for anxiety in subjects who were trying to quit smoking. Therefore, it is expected that forest-thermal combined therapy will be used as an alternative therapy that can increase the success rate of quitting smoking.

No significant differences were found in the HRV and cortisol levels, which were used as physiological indicators of stress in examining the effects of forest-thermal combined therapy. This is consistent with the finding of Jung et al. [31] that no significant effect was found in the HRV level after a three-day forest therapy program administered to female employees. In contrast, Lee et al. [17] reported a difference in LF/HF ratio, one of the HRV measures, in a study with young men who participated in a three-day forest therapy program. However, their study was conducted with nonsmokers and under substantially different conditions, in which the control group was continuously exposed to the urban environment under strict control, unlike the current study, where the control group was allowed to continue their daily routines. Similar to studies on HRV, cortisol-related results vary among studies investigating the effects of forest therapy programs. Lee et al. [17] and Ochiai et al. [19] demonstrated significant effects of forest therapy programs on cortisol. The stress-reducing effect of forest therapy is explained by the effect of phytoncide secreted by trees on the stress hormone cortisol [37]. Additionally, a forest therapy program can lead to reducing stress hormones by integrating various accompanying activities, such as exercise, yoga, and meditation, using diverse forest environmental resources [38]. Nevertheless, given the different results, such as no reduction in cortisol levels [31], as was the case with the current study, future research may focus on interstudy differences to determine the possible causes of such differences. Although there are only a very small number of studies investigating the effects of thermotherapy, there are reports of activated parasympathetic nerves, a physiological indicator of stress reduction [39,40]. In a study by Lee et al. [40], parasympathetic nerve activation induced by acupressure/heat combined massage performed on healthy men contributed to stress reduction. Jeong et al. [39] also reported a stress-relieving effect when heat and acupressure were simultaneously applied, by which physiological changes, such as HRV, were induced.

Future research on physiological changes related to stress- and anxiety-reducing effects of forest-thermal combined therapy must therefore necessary to recommend integrating frequent use of forest environment into daily living rather than participating in a short-term forest therapy camp [31], as well as investigating individual differences in the manifestation of physiological effects. That is, it is necessary to repeatedly and continuously apply the forest-thermal combined therapy to smoking cessation attempters in order to understand the long-term physiological effects of forest-thermal combined therapy. It is also necessary to examine ways to maximize the effect by running customized programs tailored to the individual characteristics of smokers willing to quit smoking.

There are several limitations to this study. First, it was conducted as a single-center study, and the number of participants was very small due to difficulties encountered amid the COVID-19 pandemic. Second, the intervention period was too short to estimate the smoking cessation success rate of the participants. Although subjects did not smoke during the intervention program, a long-term follow-up ($\geq$1 month) is necessary to properly assess the smoking cessation success rate. To evaluate the clinical effect of the forest-thermal combined therapy for smoking cessation attempters, the scope of study needs to be broadened by conducting a long-term program followed by a long-term follow-up. Third, there is a gender bias in the participants. Whether this program is effective for women needs to be verified in the future. Despite these limitations, this study remains significant for demonstrating the effects of a forest-ther-

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mal combined therapy program in reducing stress and anxiety in smokers willing to quit smoking.

CONCLUSION

The results of this study demonstrated that the proposed forest-thermal combined therapy program has a positive effect on reducing stress and anxiety in adults with smoking cessation intentions. However, no significant changes were found in the levels of cortisol, serotonin, or HRV. This highlights the need to develop an additional intervention program capable of inducing physiological changes, given the quasi-absence of case studies on forest-thermal combined therapy intervention. Additionally, as research results are accumulated, a strategy needs to be sought to integrate forest-thermal combined therapy into a smoking cessation program.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

AUTHORSHIP

CYR, LSH, KSY and CJK contributed to the conception and design of this study; LSH and KSY collected data; CYR and LSH performed the statistical analysis and interpretation; LSH drafted the manuscript; CYR critically revised the manuscript; CYR and CJK supervised the whole study process. All authors read and approved the final manuscript.

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